SEE YOU ON THE FLIPPED SIDE

The construction and testing of RF Coils used to flip ^3He polarization

National Institute of Standards and Technology
U.S. Department of Commerce

Joelle Baer

Hamilton

Presentation Overview

- What is ^3He used for at the NIST Center for Neutron Research (NCNR) ?
- How do you flip the ^3He polarization?
- What are the steps in creating and testing such a device?
- Findings from this summer's work

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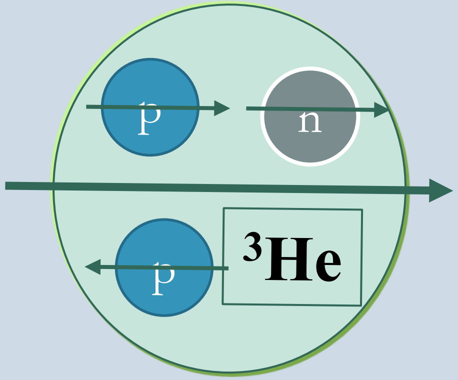
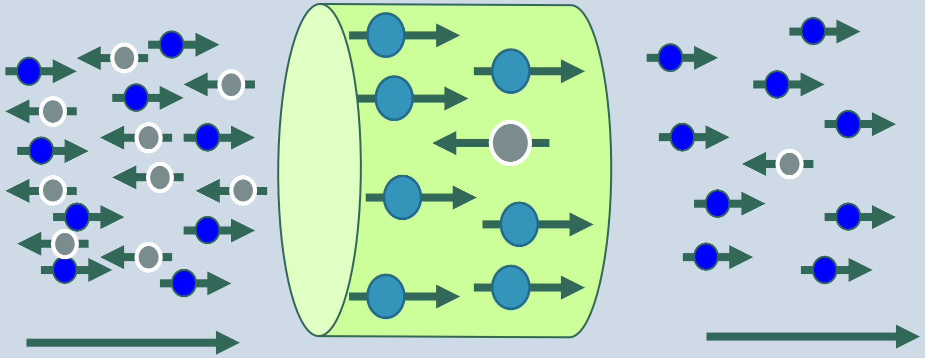
What is a ^{3}He cell?





unpolarized incoming neutrons

polarized ^{3}He

polarized outgoing neutrons

- Spin dependent neutron absorption

K.P. Coulter et al, NIM A 288, 463 (1990)

What is a ^{3}He cell?

- Back-filled with ^{3}He and a small amount of N_2
- Combination of distilled Rb/K
- Different cell characteristics

Cell for Typical Beam Size (Slider)

Wide Angle Cell (Reliance)

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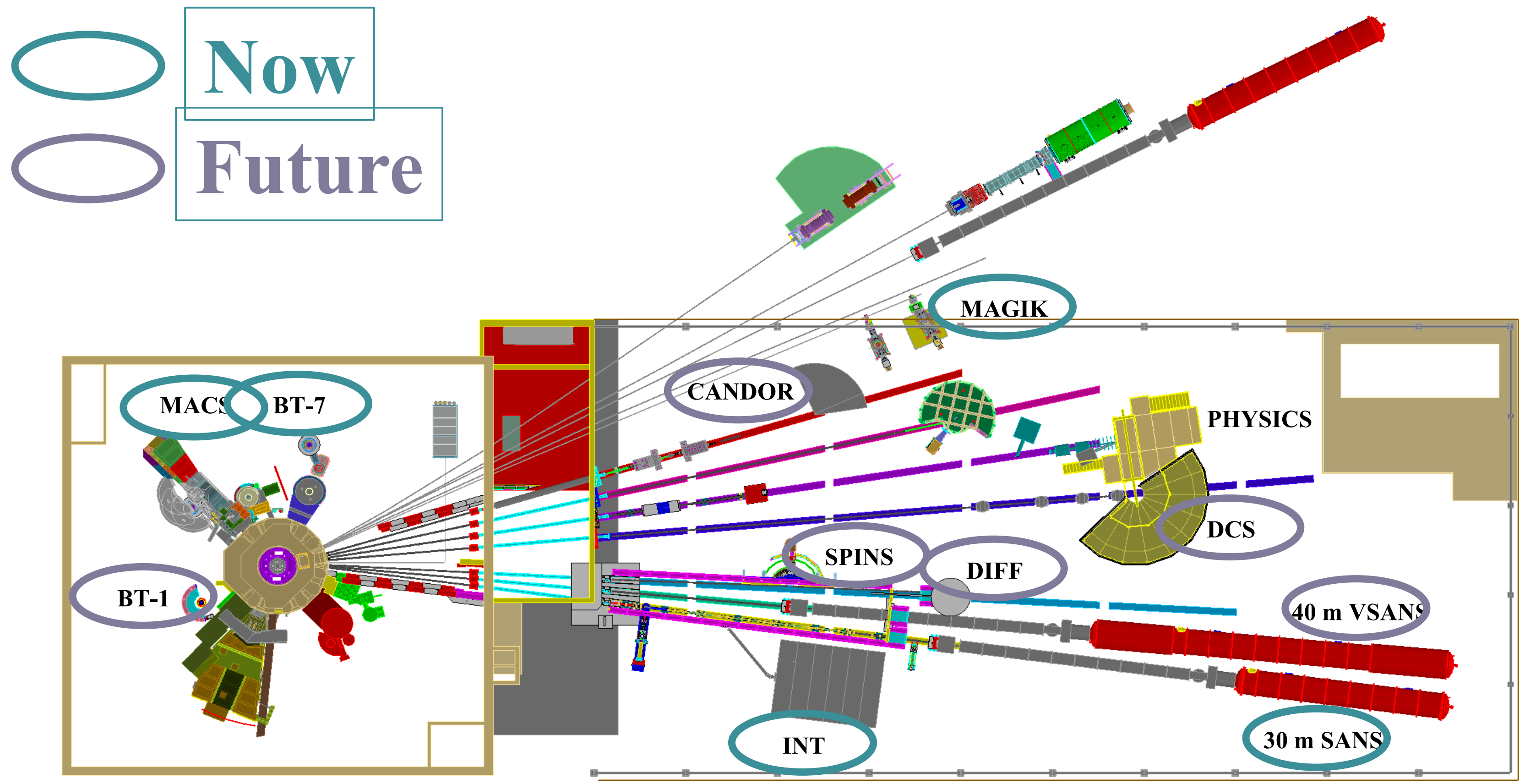
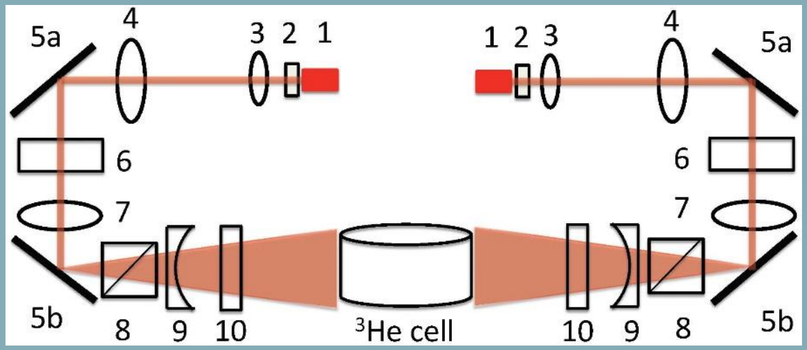
What is polarized ^{3}He used for at the NCNR?

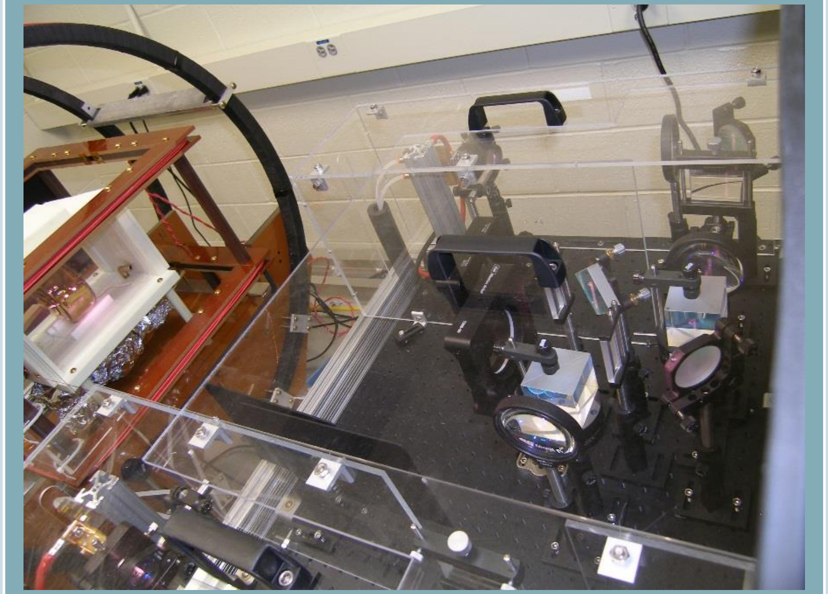


www.ncnr.nist.gov/equipment/he3nsf

Polarizing the Cell

Spin Exchange Optical Pumping (SEOP)





- Near infrared laser
- Electrons are polarized
- Spin exchange with ^{3}He
- Lengthy process

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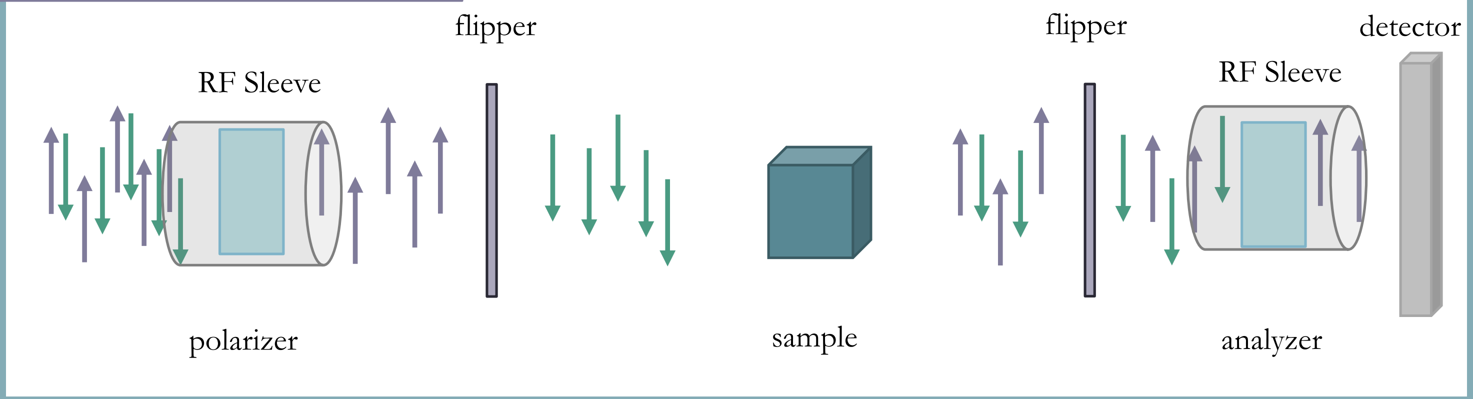
Polarization Analysis using ^3He

Cross Sections: ↑↑ ↓↓ ↑↓ ↓↑

Unconventional Set up:



- Probe magnetic properties from a sample
- Measure four cross sections
- Example: ↓↑

Flipping the ^{3}He Polarization

- B_0 Field compensation on end caps
- Neutron shielding on N end
- Sleeve creates perpendicular B_1 field
- No material in neutron beam

Vulcan

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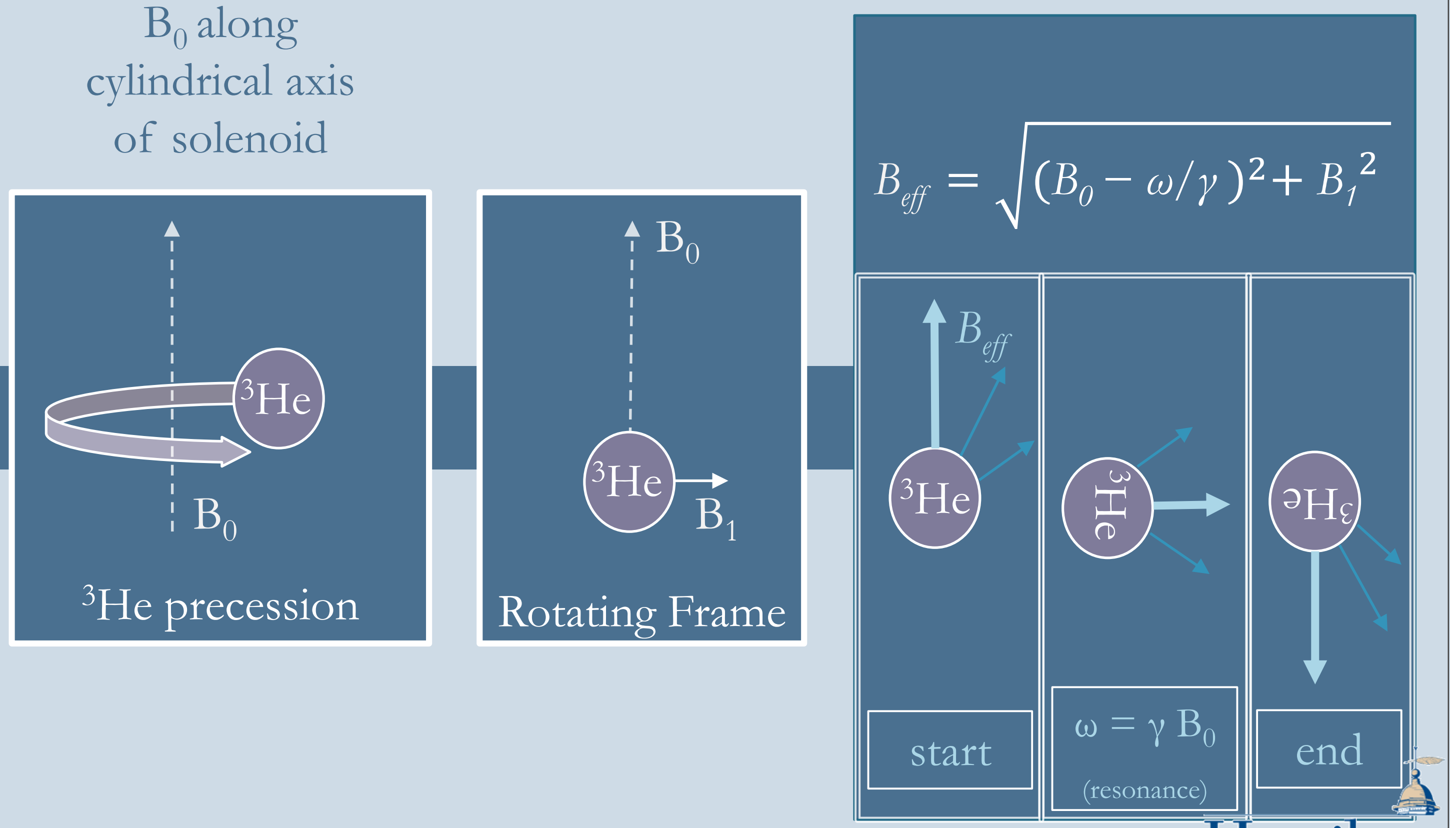
Flipping the ^{3}He Polarization

- Oscillating B-field, B_1 perpendicular to the static B_0
- ^{3}He precess around B_0
- Adiabatic Fast Passage (AFP) NMR



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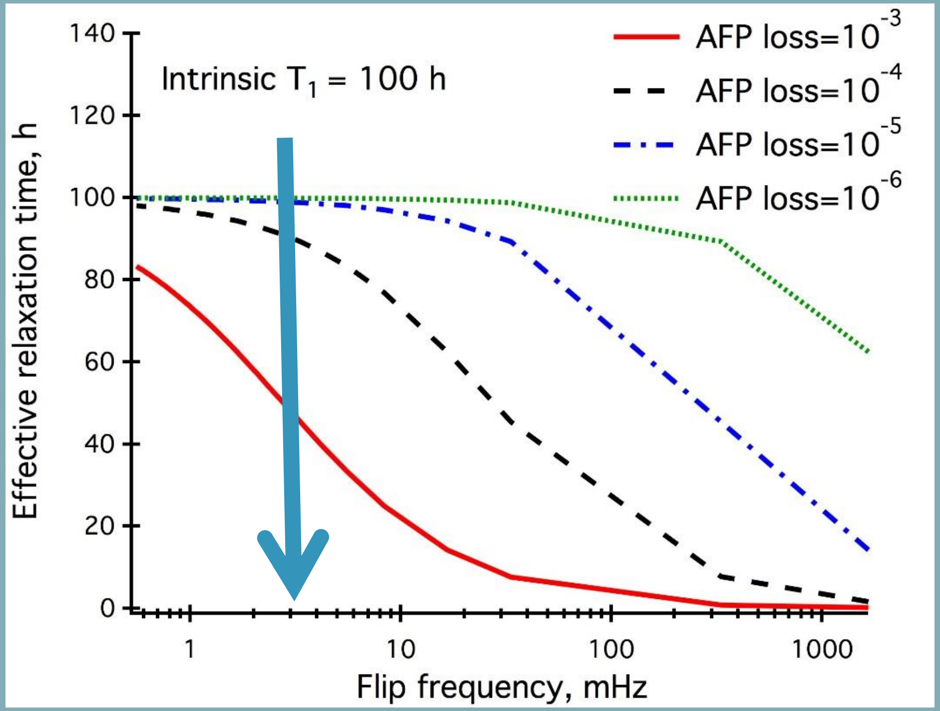
Why minimizing AFP loss is important?



To flip more often than 5 min (3.3 mHz), it is desired to have a flipping efficiency close to 0.9999 (loss of 10^{-4})

Efficiency determined by the Amplitude and Rate used in AFP NMR

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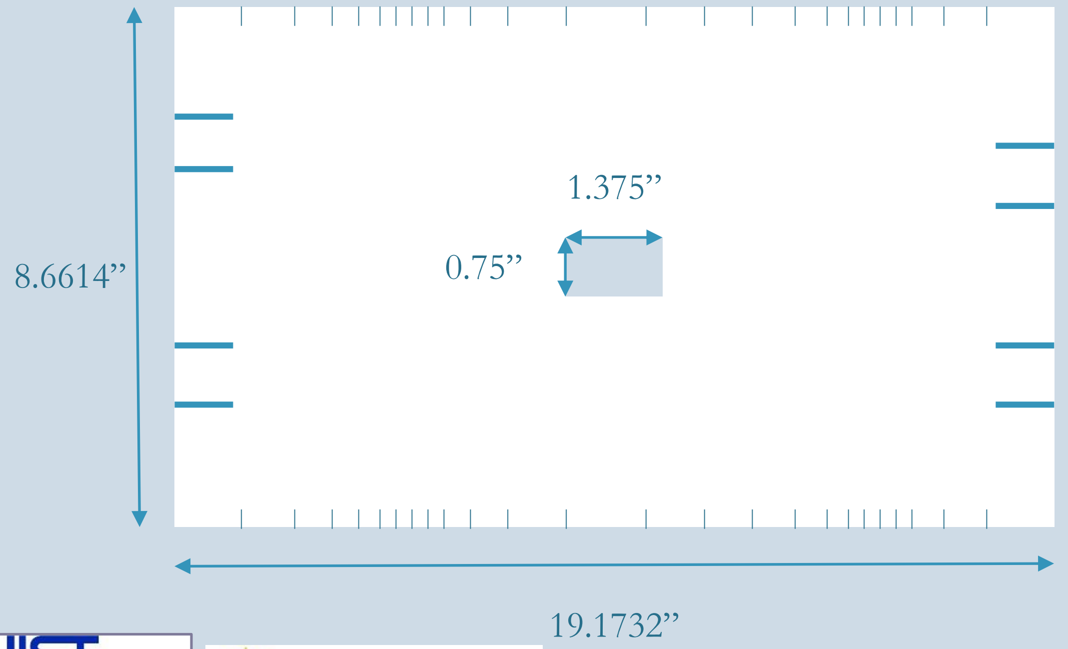
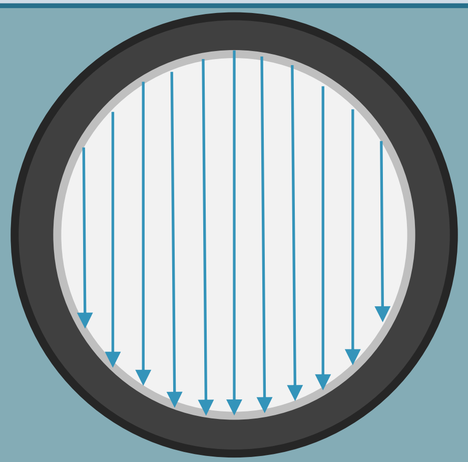
Building the RF Coil

- Sheet of Teflon rolled into a cylinder
- Hole for cell tip
- Slits in sine distribution



Sleeve in solenoid with constant B_1 due to slit distribution



Building the RF Coil

- Wound with copper wire
- Down the inside, along the rim's edge, up the inside

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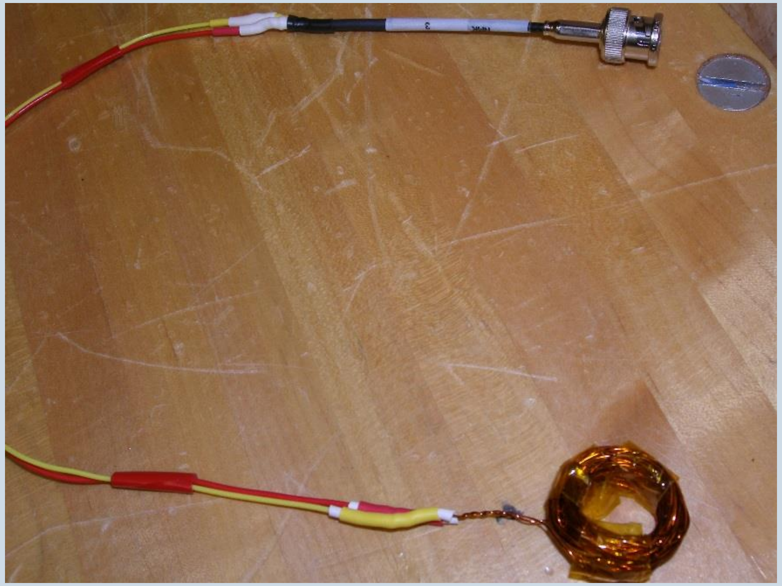
Building the FID NMR Coil

FID NMR Coil



- Free Induction Decay (FID) NMR
- Coil placed around cell tip
- Information about cell polarization and lifetime

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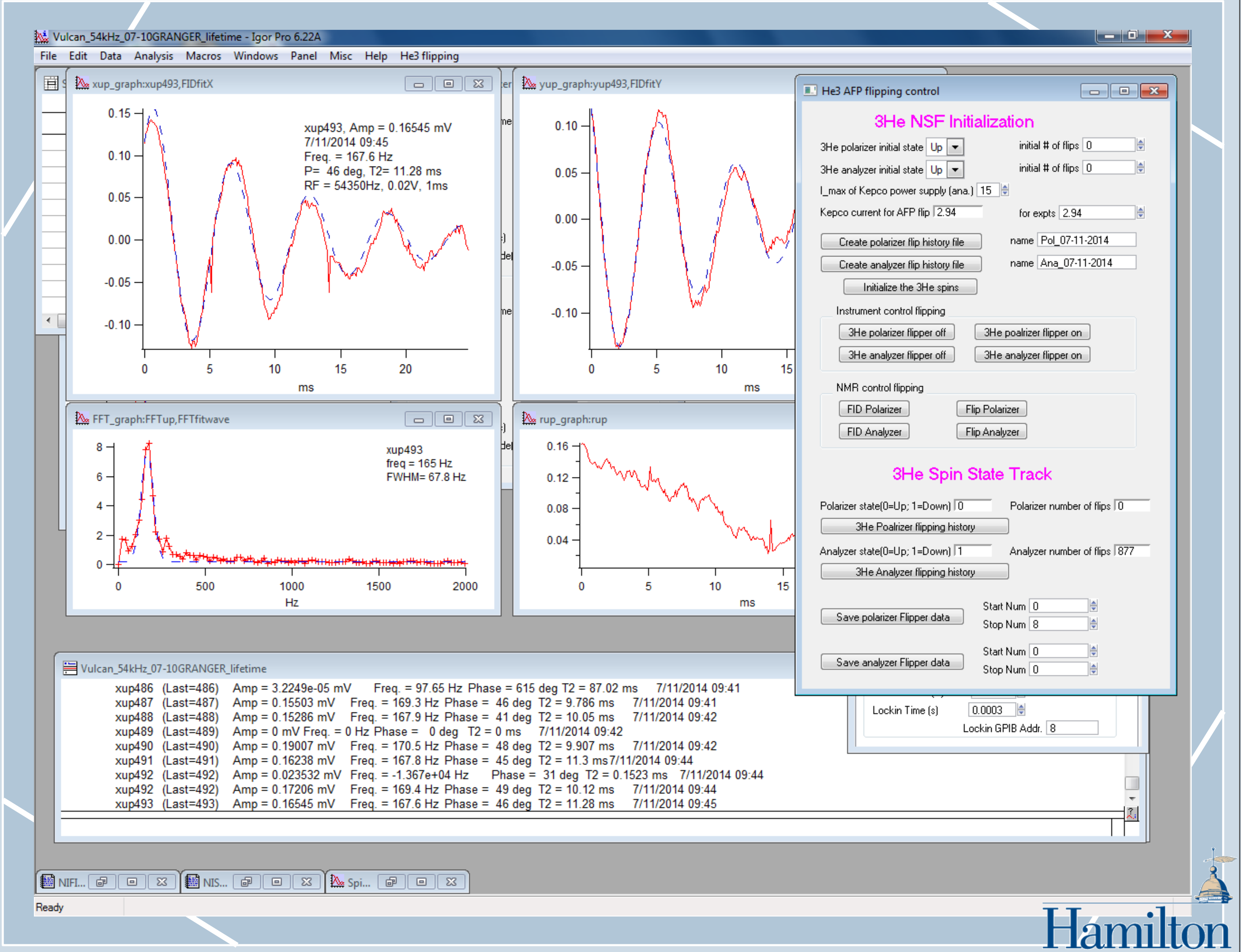
Testing the RF Coil

- Components to test:
  - Match the RF coil to the B field of the solenoids
    - For both 55kHz and 90kHz
  - Sweep amplitude for sleeve and solenoid pairs
  - Sweep rate for sleeve and solenoid pairs

Testing the RF Coil

- Information about polarization from Amplitude (Amp) and Lifetime (T2)
- Take FID NMR, flip cell, take another FID NMR



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Testing the RF Coil

Trial #	# of flips	Amp Bef	Amp Aft	Phase Bef	Phase Aft	Aft/Bef	Loss	% Loss		Aft/Bef	Loss	%Loss
Rate: 650 kHz/s										Averages		
1	2000	.07615	.07154	220	224.9	0.93942	3.125E-05	0.00312		0.93485	3.4E-05	0.00337
2	2000	.07154	.0665	224.9	229.4	0.93027	3.614E-05	0.00361				

Let $d = \dfrac{Amplitude\ After}{Amplitude\ Before}$

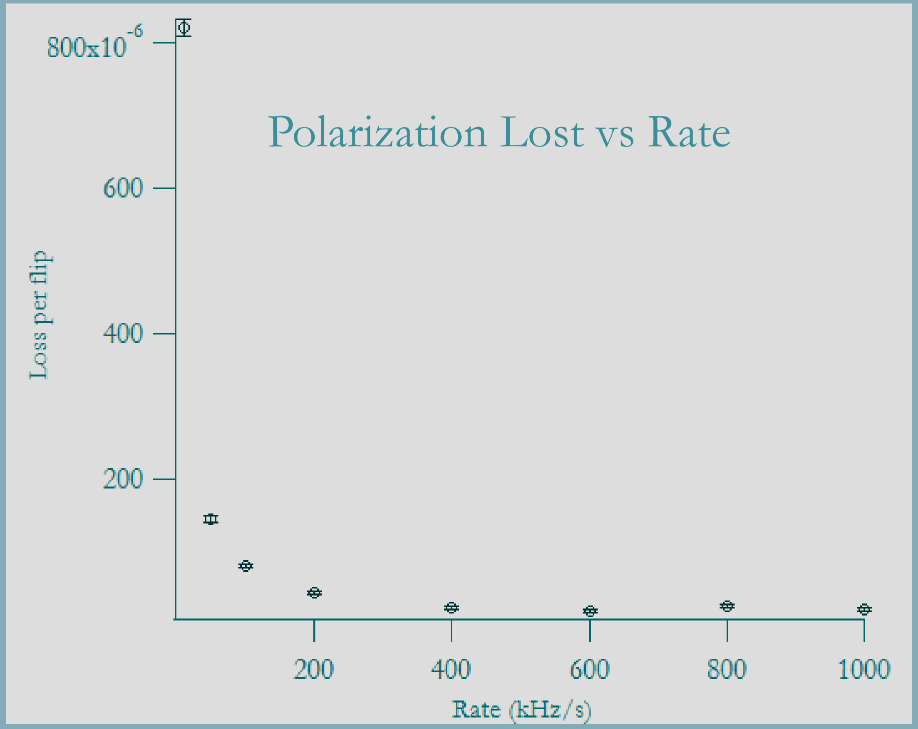
Loss = 1 - $\sqrt[\#of\ flips]{d}$

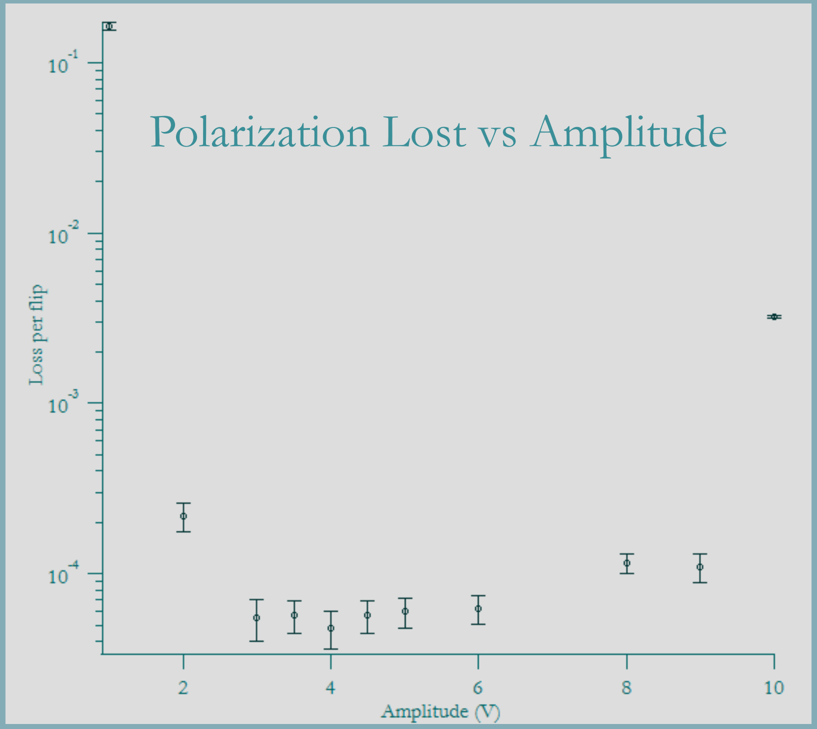
Trial 2:

$d = \dfrac{.0665}{.07154} = 0.93027$

Loss = 1 - $\sqrt[2000]{.93027} = .0000361$

Testing the RF Coil





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Parameter Results

- Weasley, Potter, and Granger all same size sleeve
- Variation in optimal settings
- Difference possible due to construction

OPTIMAL SLEEVE & SOLENOID PARAMETERS

Sleeve	Solenoid	Amp	Rate
Weasley	Gemini	2.7V	930kHz/s
Weasley	Pollux	2.9V	910kHz/s
Weasley	Vulcan	2.5V	-
		4.3 V	925kHz/s
Potter	Gemini	3.25 V	880kHz/s
Potter	Pollux	3.4 V	930kHz/s
Potter	Vulcan	2.5 V	980kHz/s
Granger	Gemini	3.6V	880kHz/s
Granger	Vulcan	3.7V	870kHz/s
Hagrid	Pollux	4.25V	650kHz/s

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QUESTIONS